VACUUM QUENCHING ASSISTED SLOT-DIE COATING FOR EFFICIENT LARGE SCALE 4-TERMINAL PEROVSKITE/SILICON TANDEM MODULES

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Fabrication of large-area semitransparent perovskite modules requires an efficient perovskite intermediate phase formation over a large surface [1]. Vacuum quenching and air-knife quenching are two most employed methods in the manufacturing of perovskite solar modules [2]. This work highlights the advantages of vacuum quenching over air-knife quenching based on current research and practical applications. Vacuum quenching offers superior control over the drying process, ensuring uniformity in film formation and minimizing defects such as pinholes and cracks. By eliminating air turbulence, vacuum quenching reduces surface roughness and enhances the interface quality between layers, thereby improving charge carrier transport and device efficiency. The P-I-N mini-modules implementing these vacuum-quenched perovskite layers deliver efficiencies exceeding 15% and 12.5% over 64 cm² and 174 cm² large areas, respectively, with an excellent V_{OC} over 32 Volts of the champion device. The 4-terminal tandem module, which is mechanically stacked by the perovskites and bifacial silicon modules, shows an efficiency of 21.5% on an area of 64cm² and 24.93% when accounting for bifaciality. These encouraging results position vacuum quenching as a promising technique for enhancing the performance of perovskite solar modules towards industrial applications.

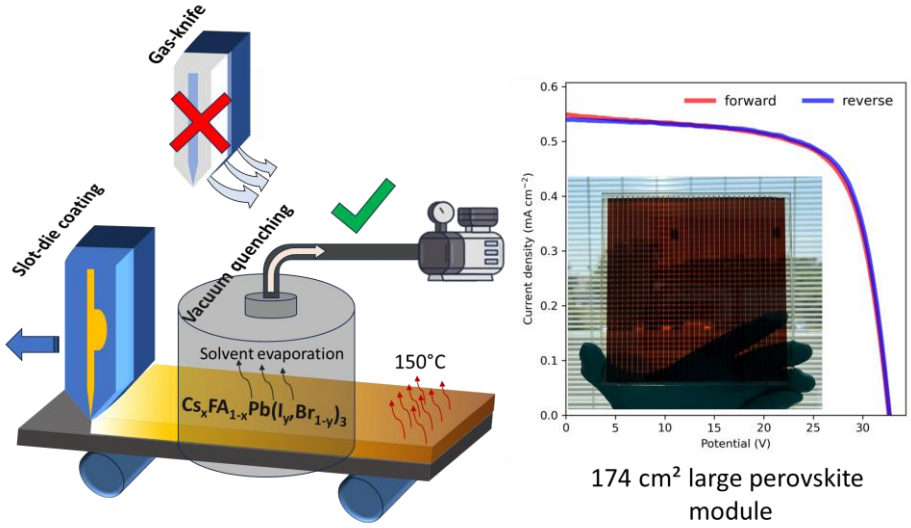

***Figure 1**: Vacuum-assisted Slot-die coating in ambient atmospheric conditions and the I-V curve of the fabricated 13.2x13.2cm² large area semi-transparent perovskite submodule.*

[1] Gu et al. ACS Appl. Mater. Interfaces 2022, 14, 2949-2957
[2] B. Yan et al., Science 388, eadt5001 (2025)